



Evaluation of Potential Enhancements to Version 6 Cloud Clearing and Profile Retrieval

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AIRS Science Team Meeting

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Outline

- **Overview of recent work – improving performance in most difficult cases:**
 - Land
 - Elevated surface terrain
 - Near polar regions
- **SCC+NN performance comparisons with AIRS L2 Version 5 algorithm (versus ECMWF and Radiosondes)**
- **IASI versus AIRS: SCC/NN temperature retrieval performance**
 - Importance of high SNR in SW spectral region
- **Possible Version 6 enhancements (regression first guess, etc.)**
- **Future Work**



Retrieval Performance Validation with AIRS/AMSU

Case 1: ECMWF atmospheric fields

- >1,000,000 co-located AIRS/AMSU/ECMWF observations from ~100 days:
 - Every fourth day from December 1, 2004 through January 31, 2006
 - Used for training
- ~250,000 profiles set aside for validation and testing sets

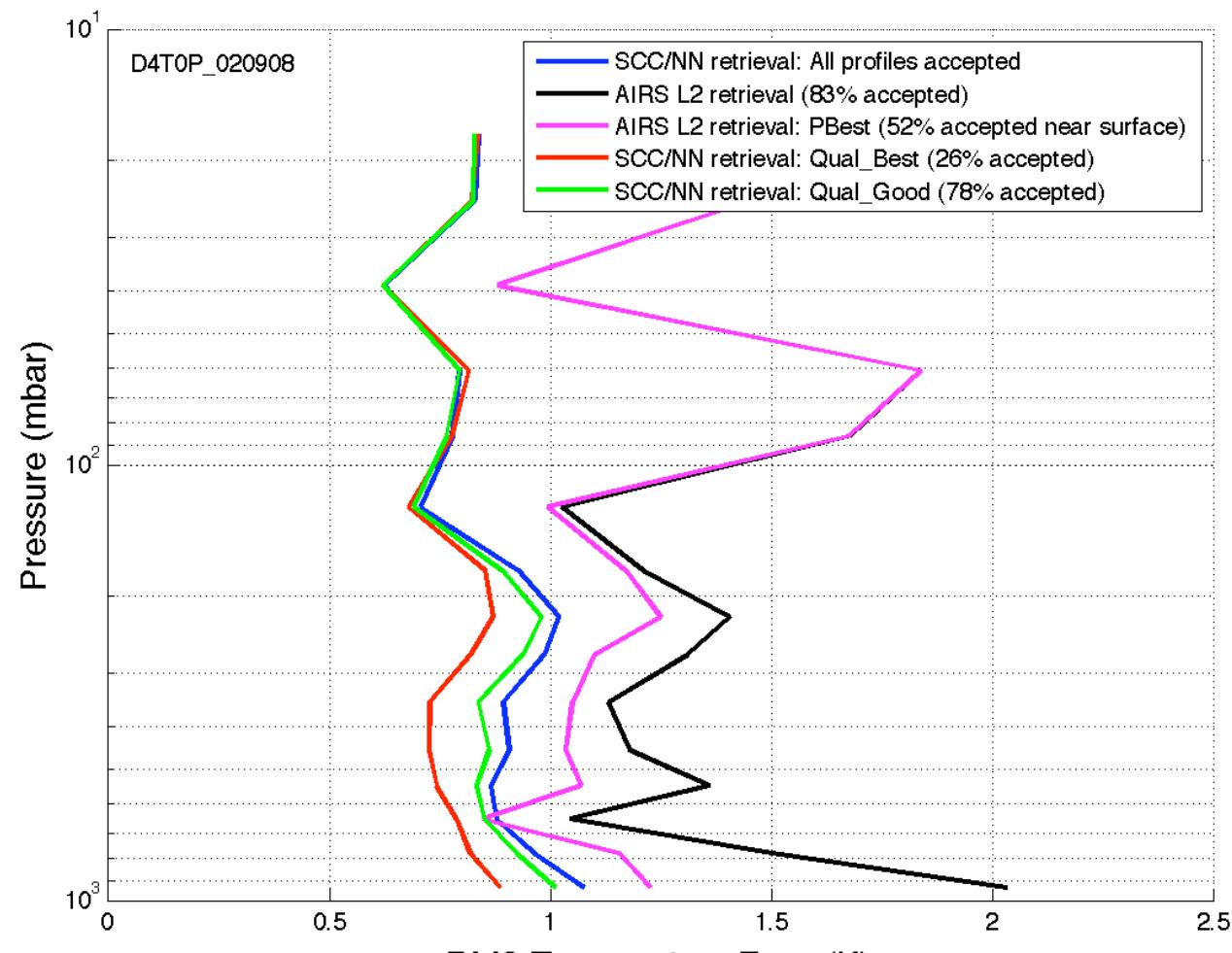
Case 2: Radiosonde data

- ~50,000 quality-controlled radiosondes from NOAA FSL global database co-located with AIRS/AMSU observations
 - Used for validation

Global: Cloudy, Land & Ocean, Day & Night



SCC/NN versus AIRS L2 (Version 5) Descending, Ocean, Edge-of-Scan, Spring05



~1km vertical layers
AIRS+AMSU

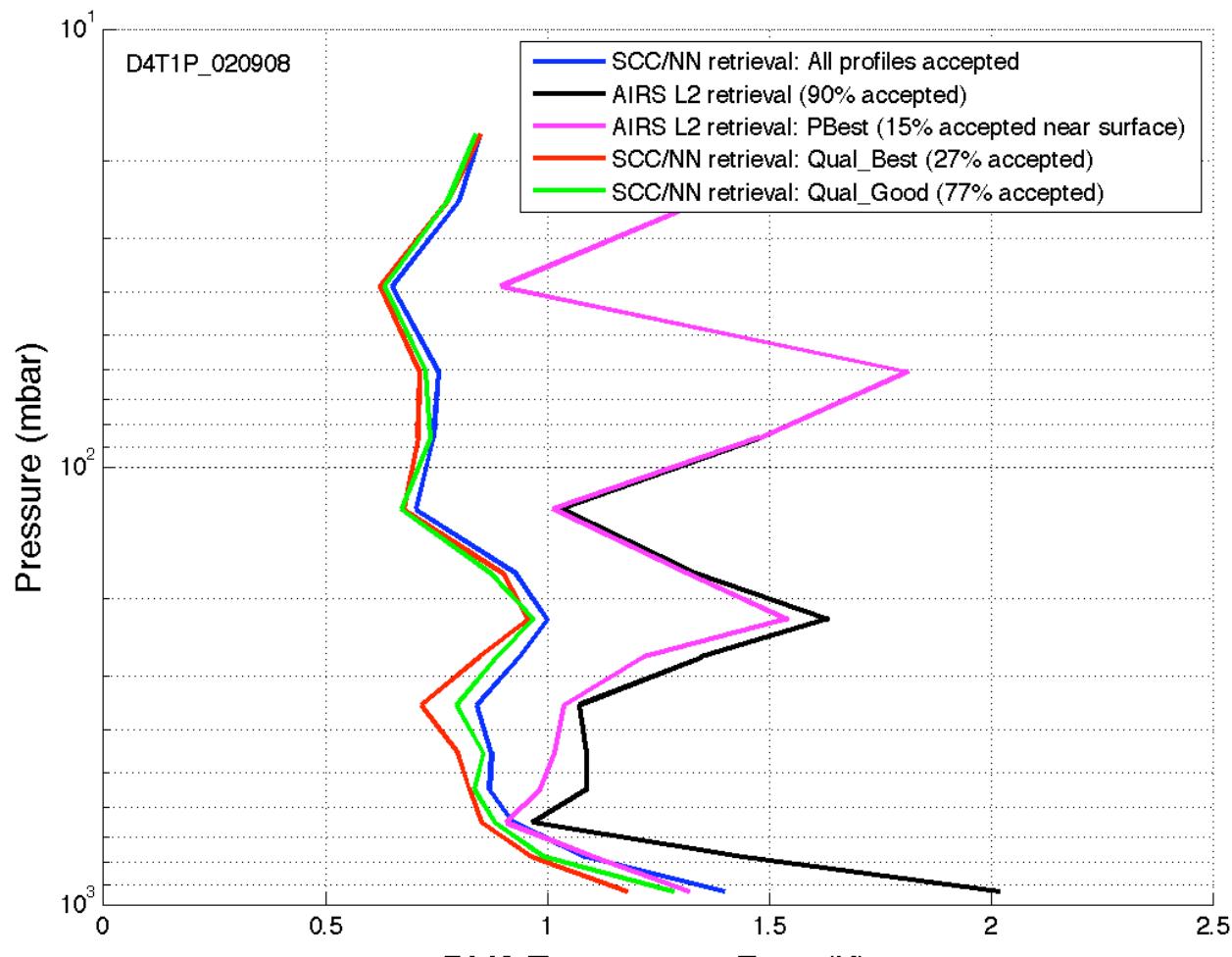
Latitudes within $\pm 60^\circ$

ECMWF is “truth”

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SCC/NN versus AIRS L2 (Version 5) Descending, Land, Edge-of-Scan, Spring05



~1km vertical layers
AIRS+AMSU

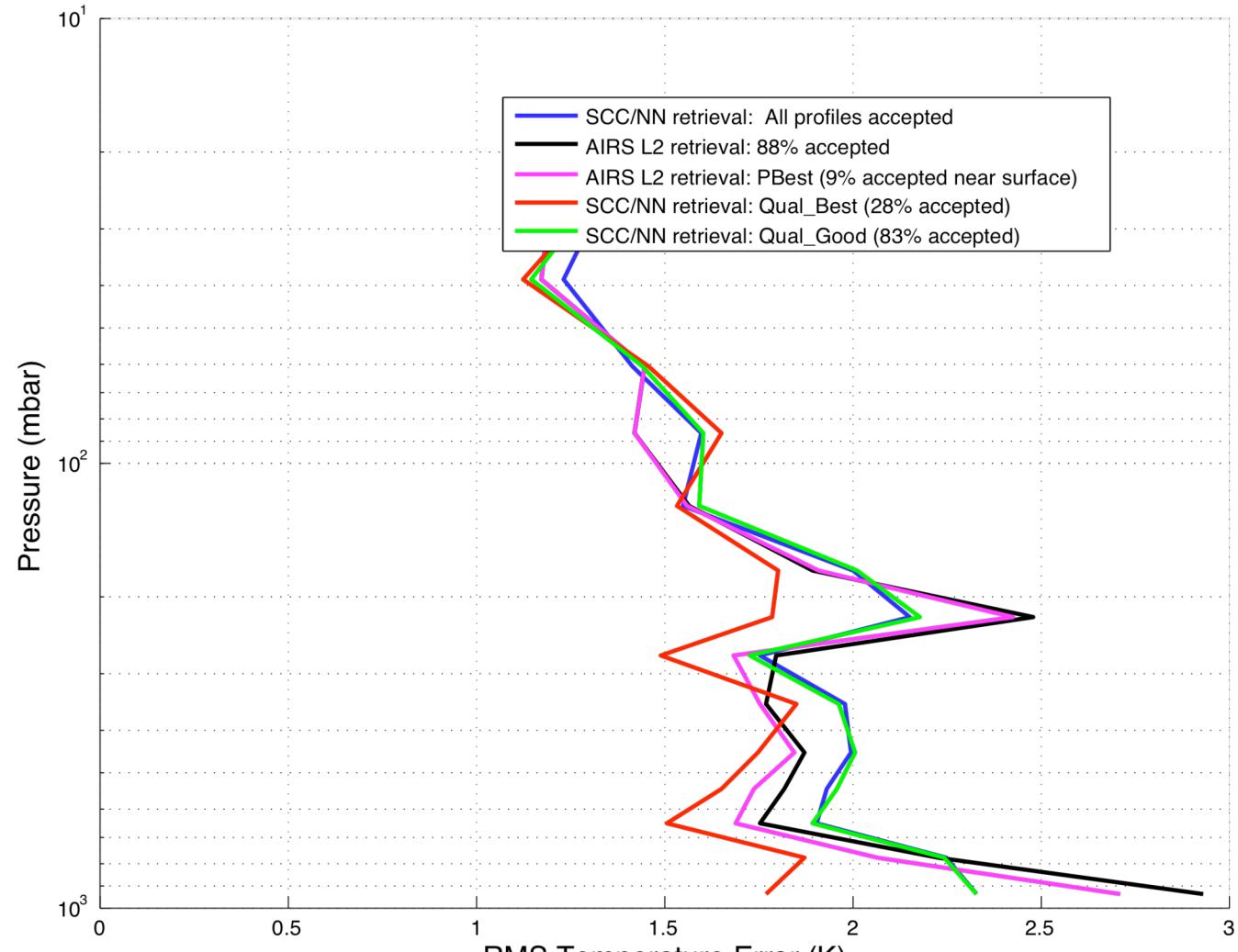
Latitudes within $\pm 60^\circ$

ECMWF is “truth”

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Descending, Land, Edge-of-Scan, Spring05 Versus Radiosondes



~1km vertical layers
AIRS+AMSU

Latitudes within $\pm 60^\circ$

910 radiosondes are “truth”

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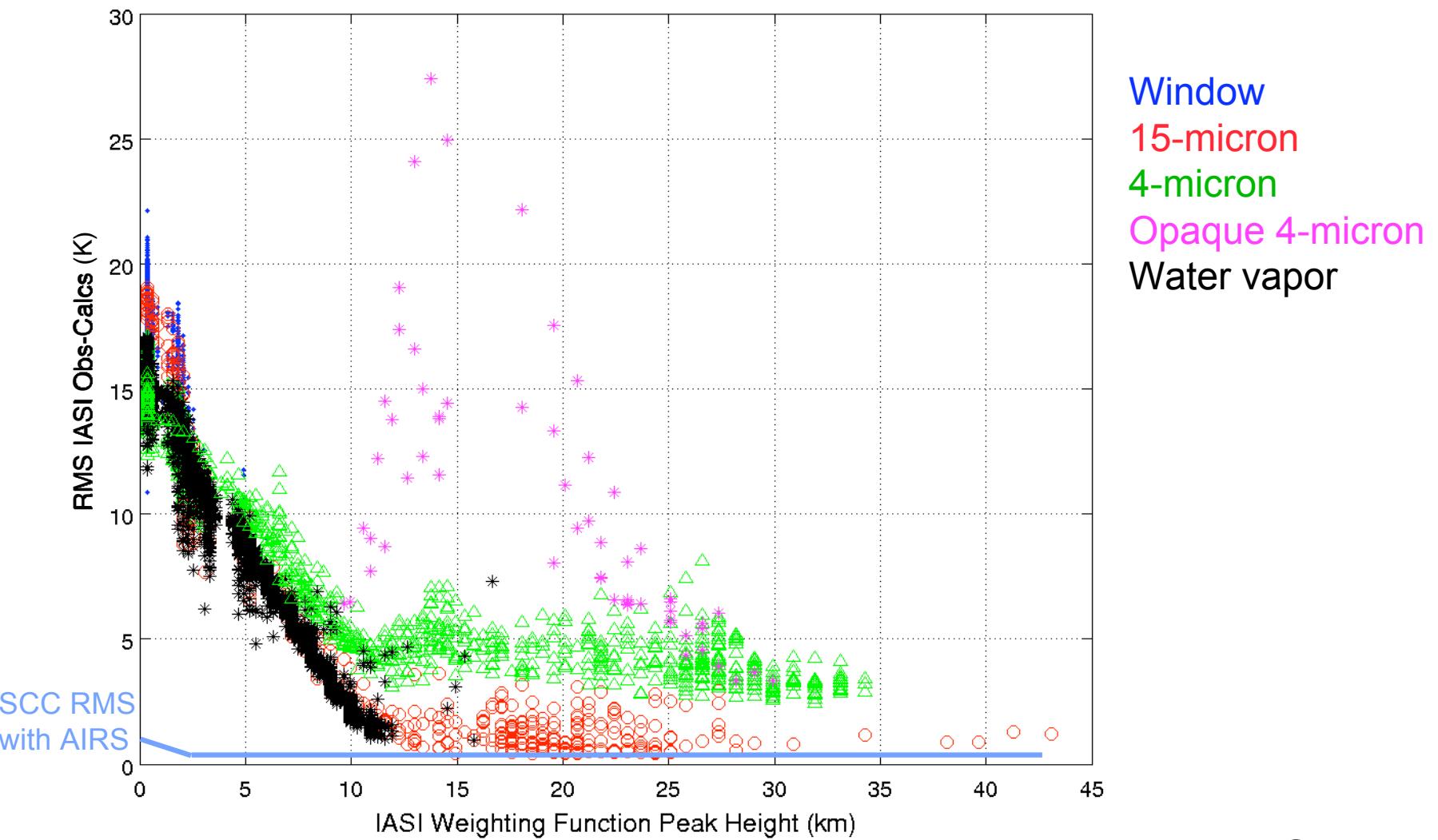


IASI/ECMWF/SARTA Matchup Database

- Global database spanning May07-Dec07
- Approximately 100,000 fields-of-regard
 - IASI observations (2x2)
 - ECMWF atmospheric fields
 - Radiosondes (available for some FOR's)
 - IASI clear-air spectra calculated with SARTA v1.05
- Database stratified by surface type, latitude, solar zenith angle, sensor scan angle, surface pressure



RMS IASI Cloudy Obs - Clear Calcs (i.e., Before Cloud Clearing)

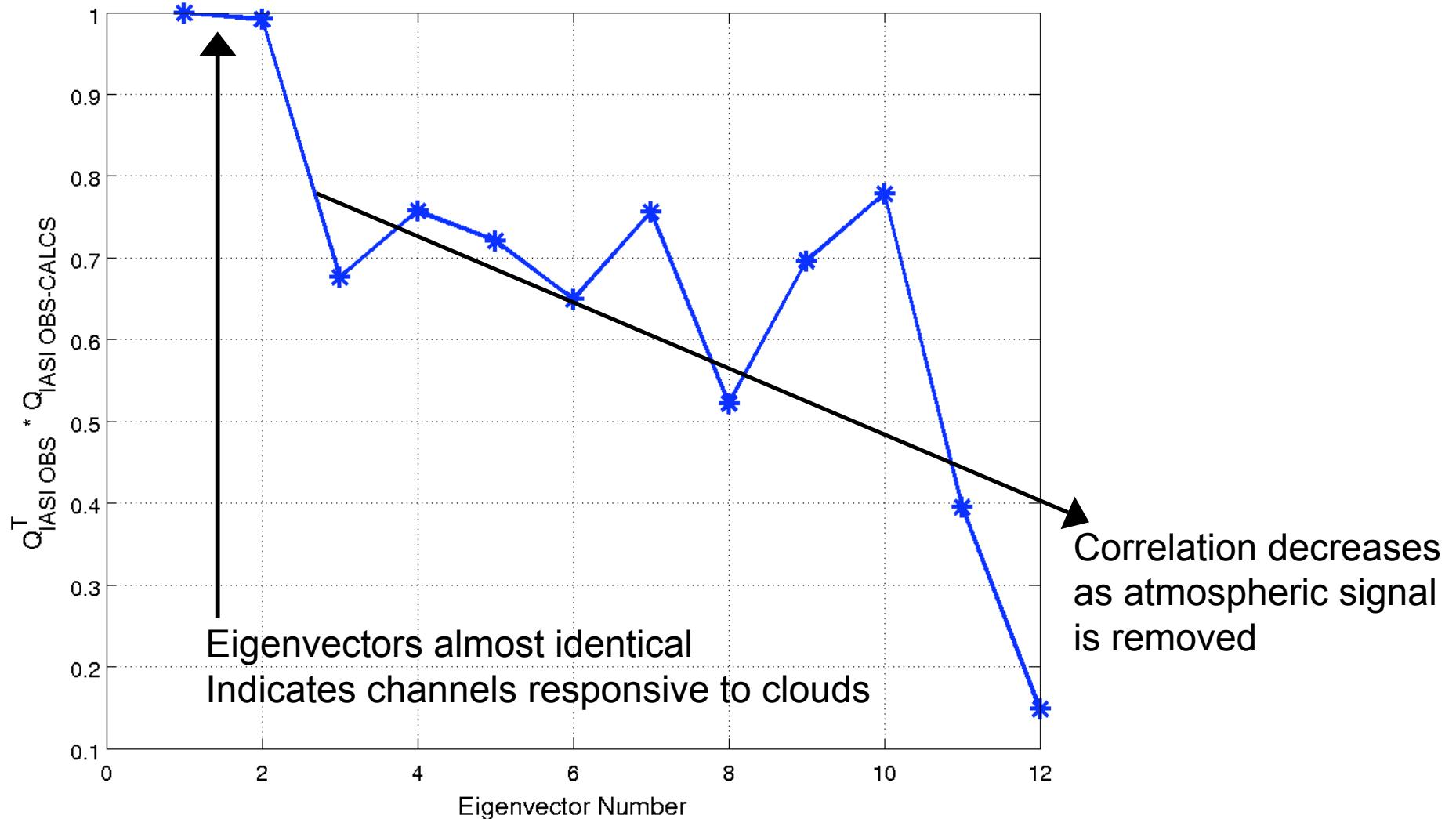


Ocean

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Correlation of “IASI OBS” and “IASI OBS-CALCS” Eigenvectors

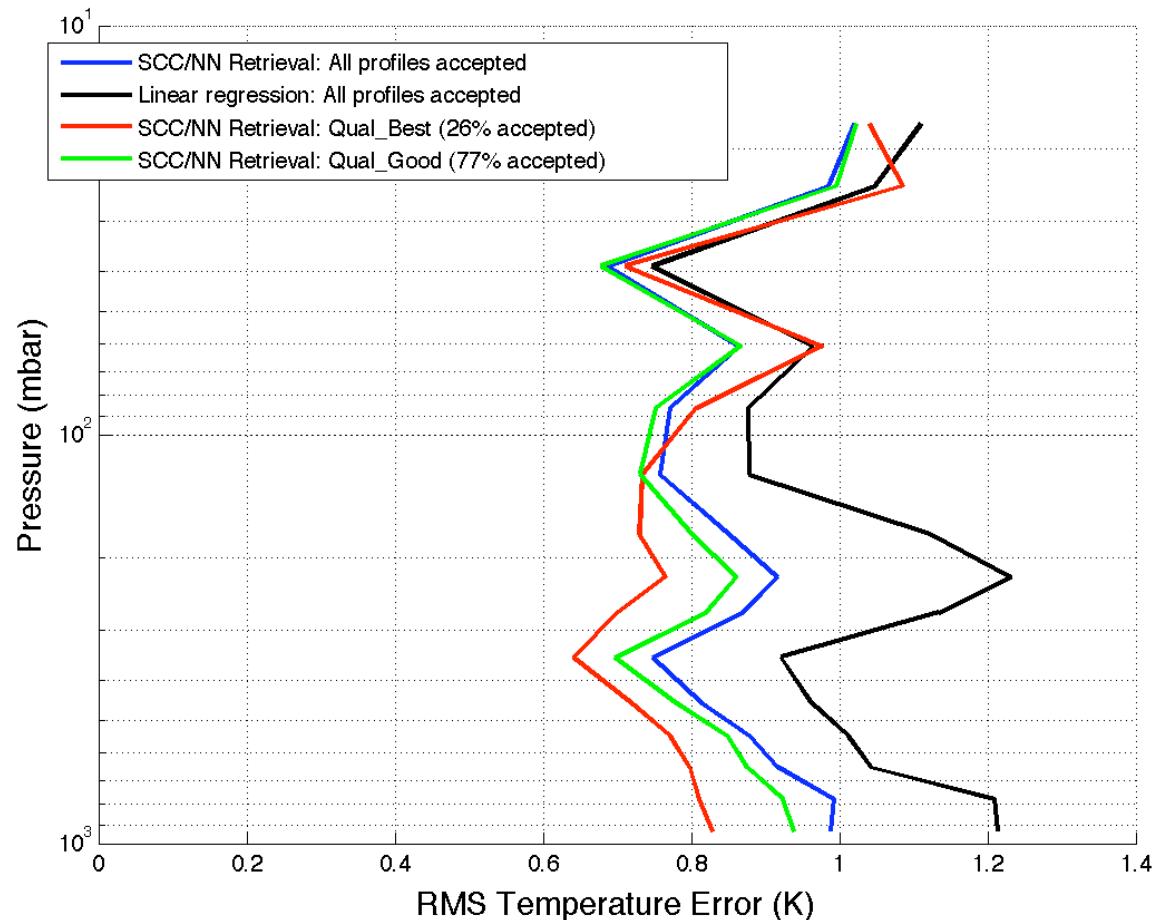


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IASI Temperature Retrievals Over Ocean



~1km vertical layers
IASI+AMSU

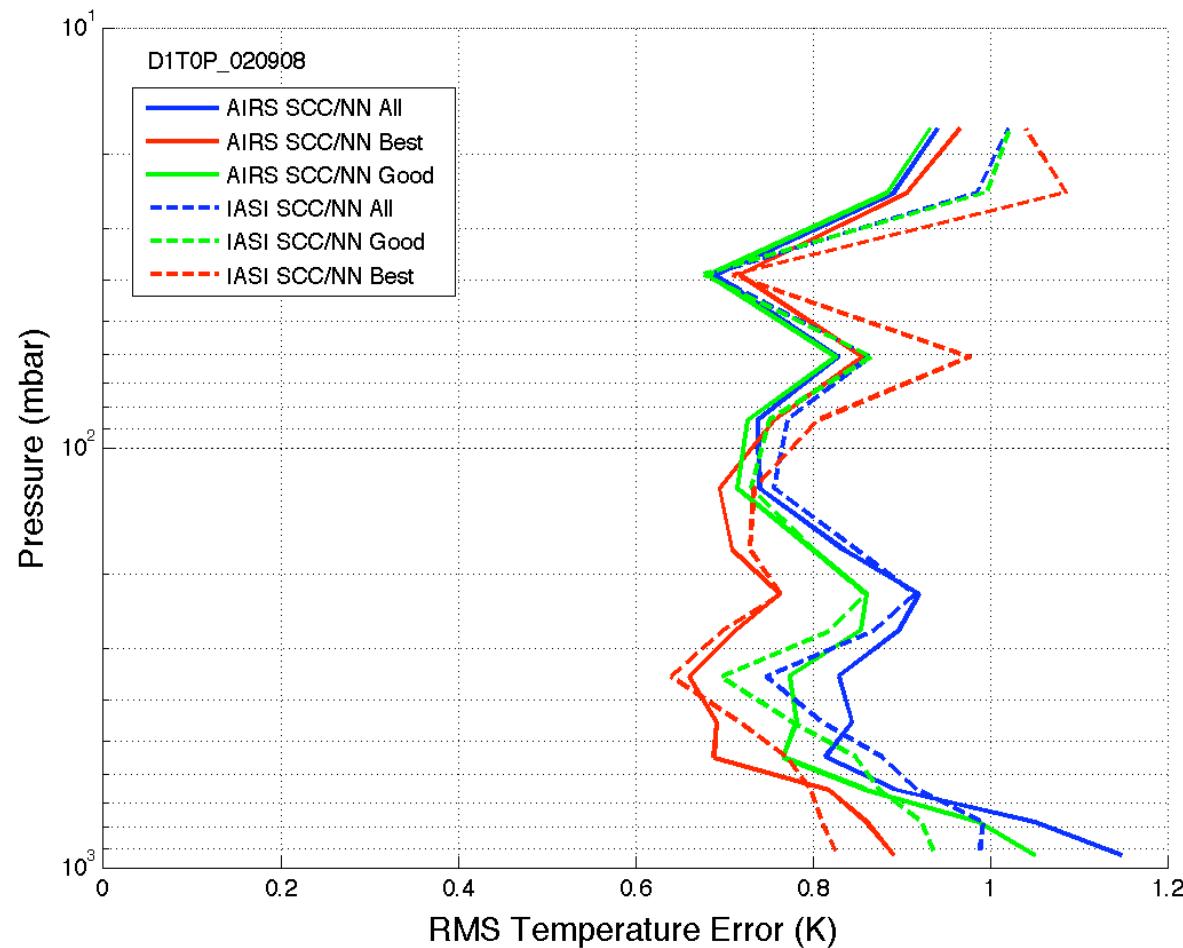
Near-nadir scan angles, $\pm 60^\circ$ Latitude

ECMWF is “truth”

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AIRS versus IASI: Ocean



~1km vertical layers
IASI+AMSU

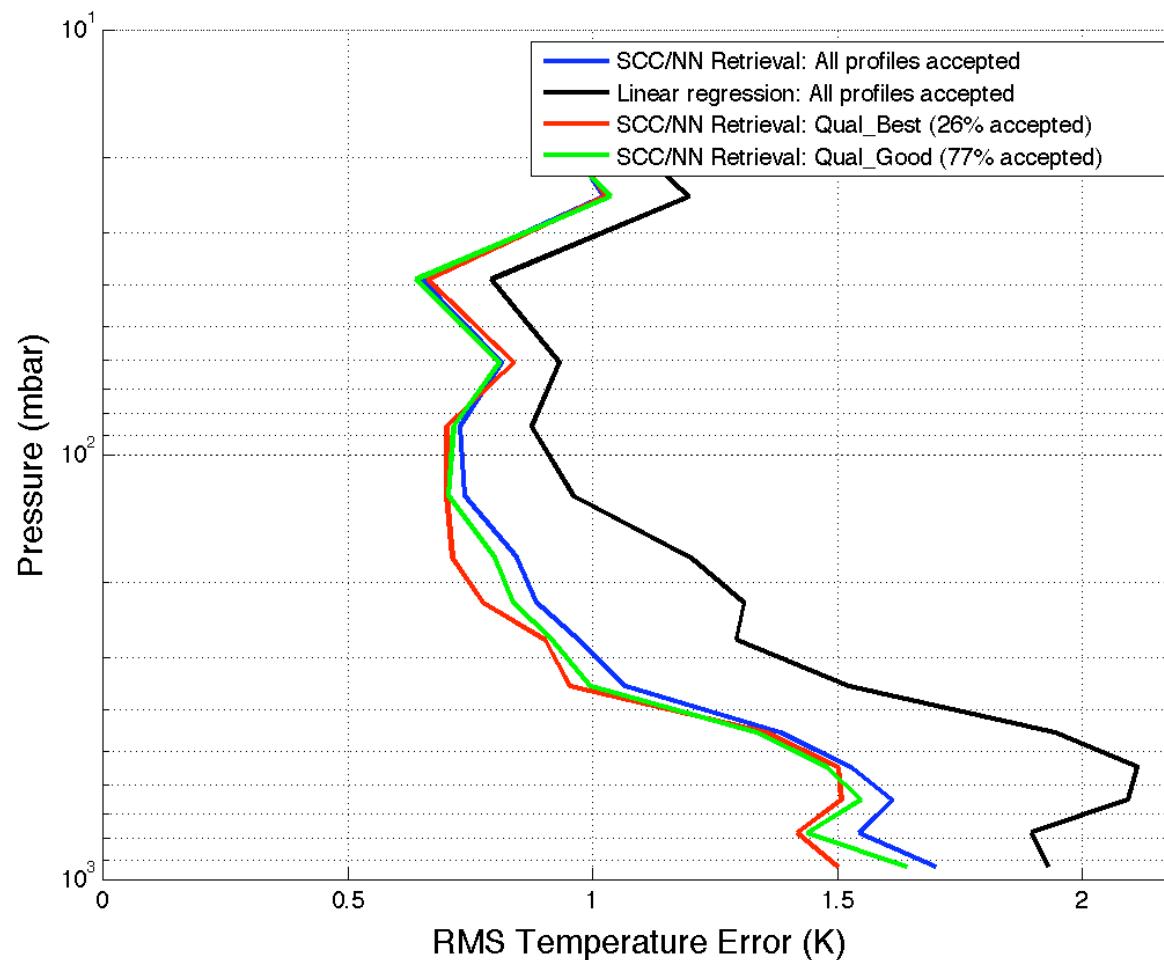
Near-nadir scan angles, $\pm 60^\circ$ Latitude

ECMWF is “truth”

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IASI Temperature Retrievals Over Land



~1km vertical layers
IASI+AMSU

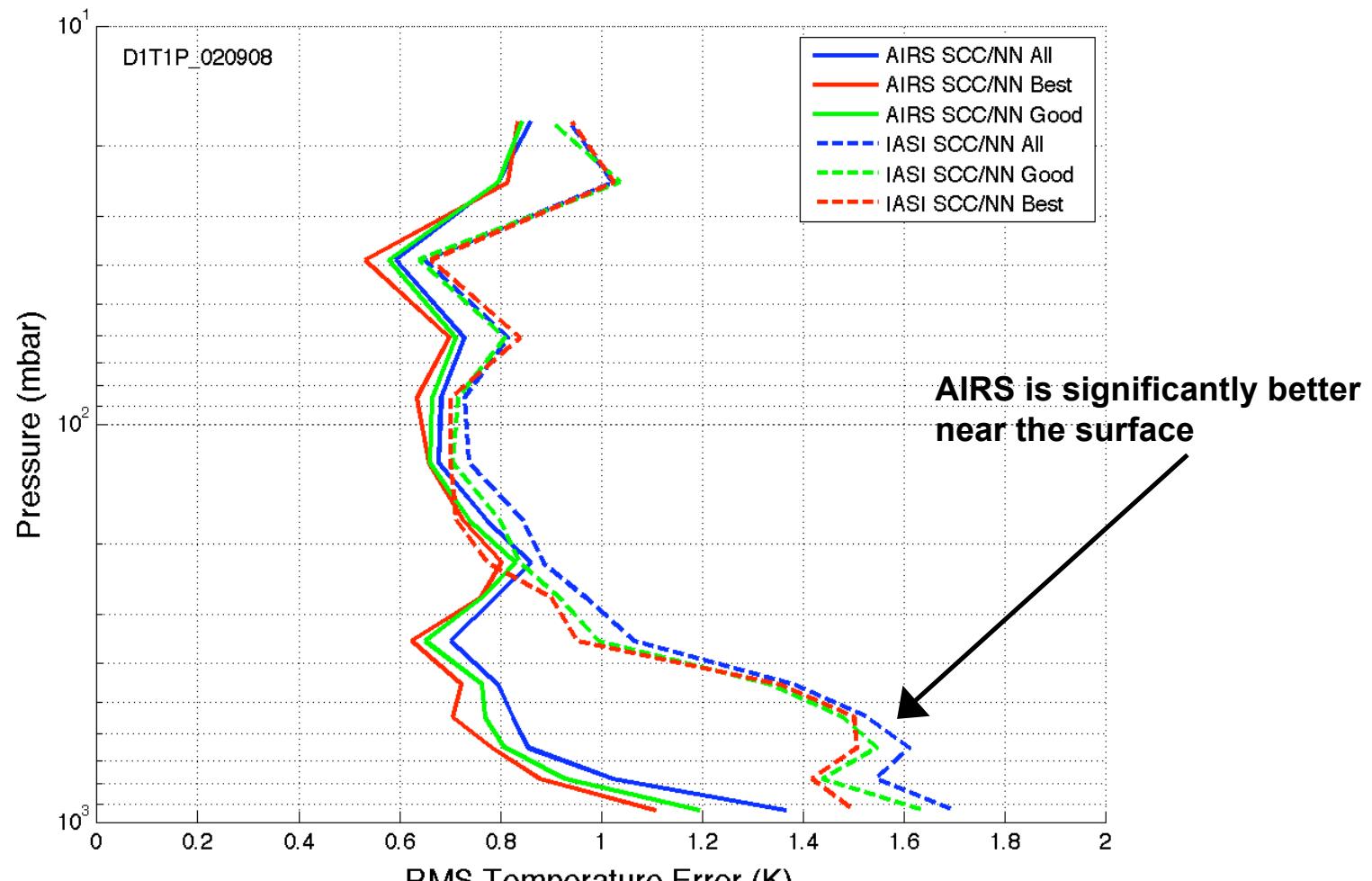
Near-nadir scan angles, $\pm 60^\circ$ Latitude

ECMWF is “truth”

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AIRS versus IASI: Land



~1km vertical layers
IASI+AMSU

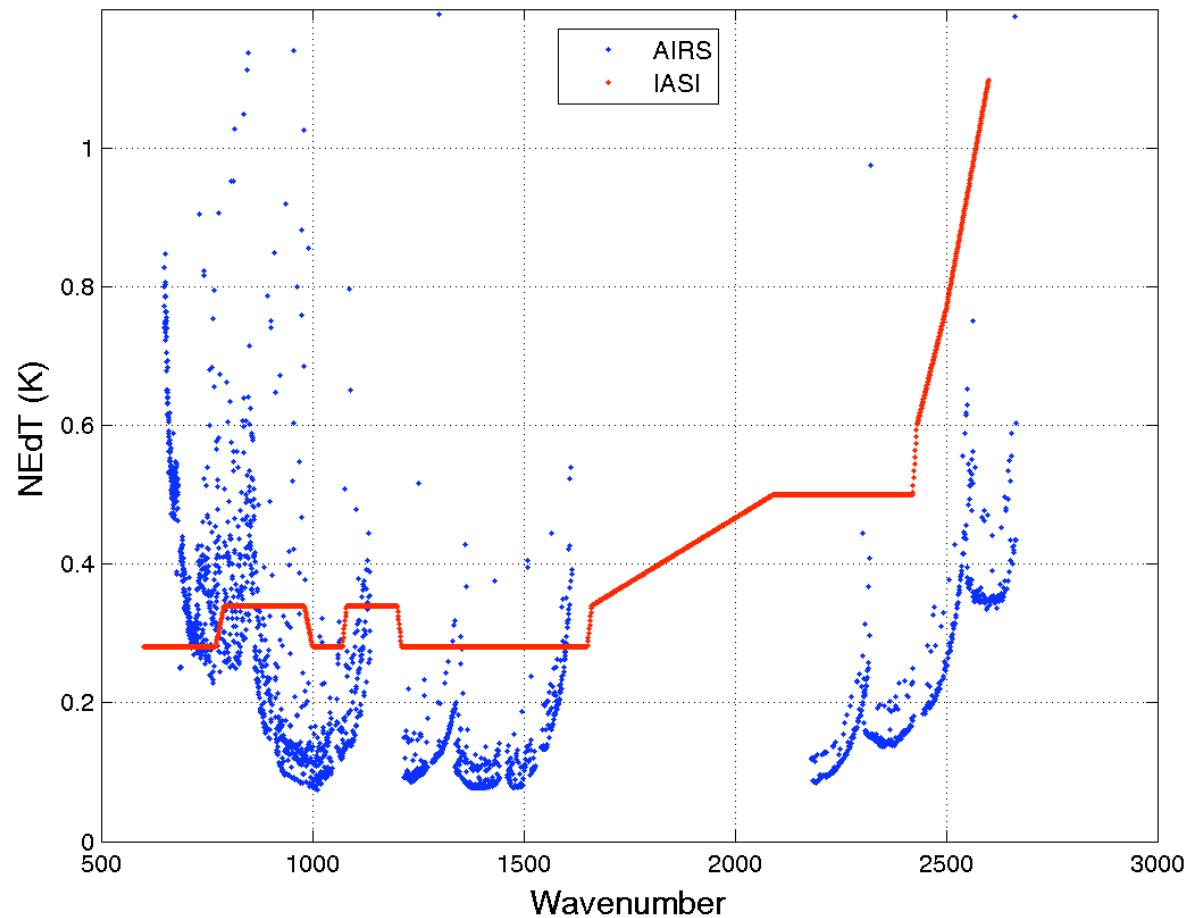
Near-nadir scan angles, $\pm 60^\circ$ Latitude

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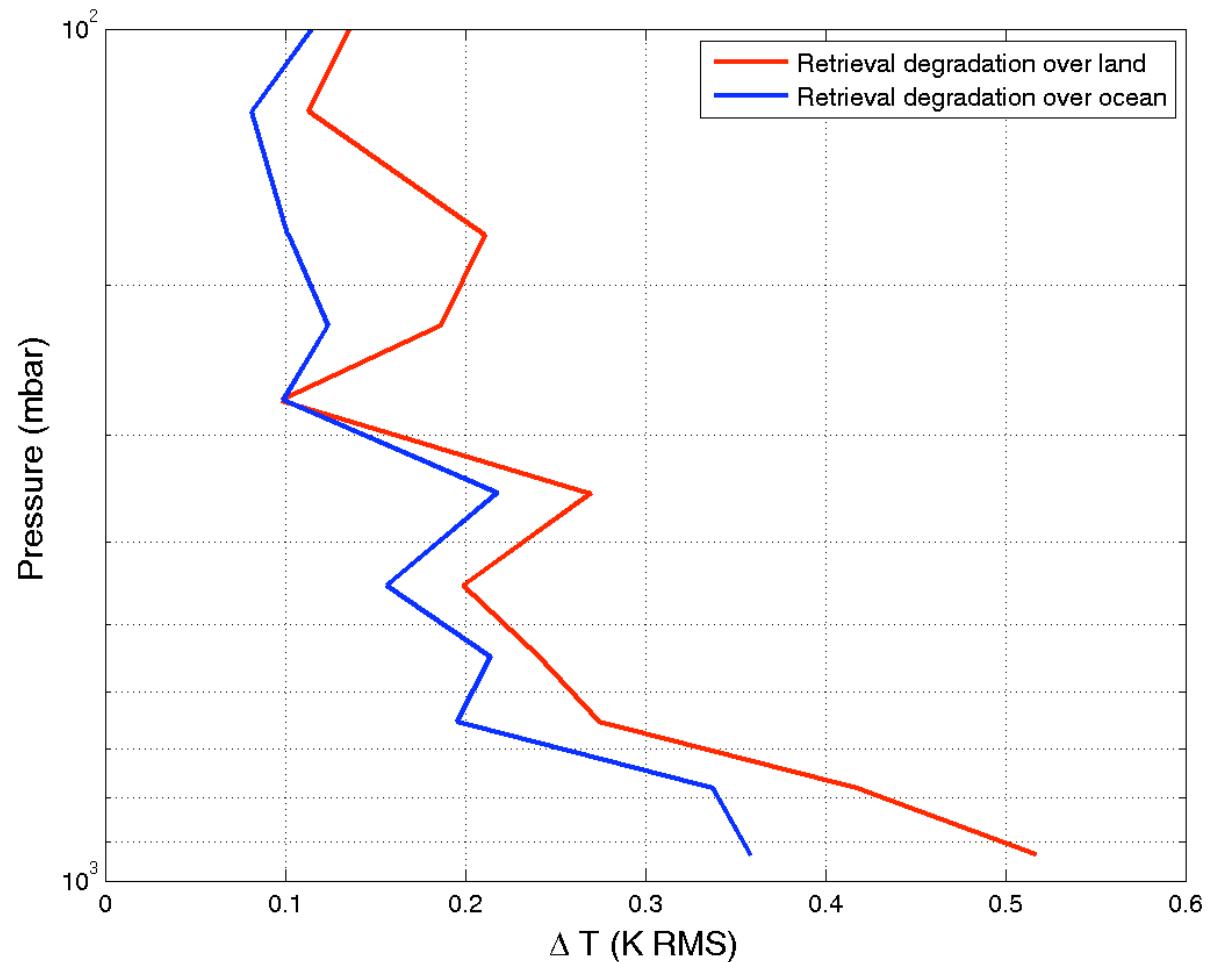


AIRS versus IASI NEdT





AIRS Retrieval Degradation After Adding Noise to Shortwave Channels



~1km vertical layers
IASI+AMSU

Near-nadir scan angles, $\pm 60^\circ$ Latitude

ECMWF is "truth"

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Potential Advantages SCC/NN “First Guess” Could Offer v6

- Lower trend biases due to first guess
 - Coefficients sets are derived from several stratifications:
Season, latitude, surface pressure, surface type, solar zenith angle
- Higher yield/accuracy in critical areas
 - Land
 - Polar
 - Heavy clouds
- Lower sensitivity to changing/degrading instrument properties
 - For example, preliminary analysis of AMSU ch4 degradation has minimal impact on SCC/NN products



Steps in Version 5 and Version 5.12 (Courtesy Joel Susskind)

MIT AMSU Retrieval

- $X^{NN} \xrightarrow{?}$ Cloudy regression gives X^{CR}
- X^{CR} AMSU Retrieval using X^{CR} gives $X^{\text{microwave}} = X^0$ (now solve for $T(p), \varepsilon_v$ only - not T_s)
- $\hat{R}_i^{SCC} \xrightarrow{?}$ Determine $\hat{R}_i^0, \alpha^0, P_c^0$ using X^0
- $X^{NN} \xrightarrow{?}$ Determine X^{reg} from \hat{R}_i^0
- X^{reg} AMSU retrieval using X^{reg} gives X^1 (now solve for $T(p), \varepsilon_v$ only - not T_s)
- $\hat{R}_i^{SCC} \xrightarrow{?}$ Determine \hat{R}_i^1 using X^1
- \hat{R}_i^1 Physical retrieval using \hat{R}_i^1 and X^1 gives X^{PHYS}
- X^{PHYS} AMSU retrieval using X^{PHYS} gives X^{test}
- \hat{R}_i^2 \hat{R}_i^2 determined from X^{PHYS}
- \hat{R}_i^2 Physical retrieval using \hat{R}_i^2 gives X^{final}
- $X^{NN} \xrightarrow{?}$ Select X^0 or X^{final}
- X^0 Clouds, OLR determined from X^0 or X^{final}
- X^{final} Generate error estimates
- δX
- Do QC

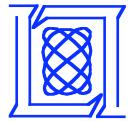
Steps Modified in Version 5.12

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Future Work / Conclusions

- Additional and more extensive performance assessments
 - Experiments to illuminate possible paths of integration with AIRS Level 2 algorithm (v6)
 - Match-ups with RAOB data
- Algorithm optimizations, especially for IASI/CrIMSS
 - Improved handling of land, including elevated surface terrain and surface emissivity
- Comprehensive performance assessments with ECMWF and Radiosondes continue to show encouraging results for SCC/NN
- Potential enhancements to v6 include: Lower trend biases, higher yield/accuracy, less sensitivity to sensor degradation



Backup Slides

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Algorithm Overview (Part I)

- Temperature and moisture profile retrievals are produced in all cloud conditions
- Cloud-cleared radiance estimates are produced for all 2378 AIRS channels
- Retrieval is global:
 - All latitudes
 - Ocean and land
 - Day and night
- Quality control has been implemented
- IR-only option implemented
- Very fast: Cloud-cleared radiances and retrieved profiles generated for one field of regard in ~1 msec using PC!!
 - Two-three orders of magnitude faster than current operational methods
 - One-two orders of magnitude faster than iterative, pseudochannel methods

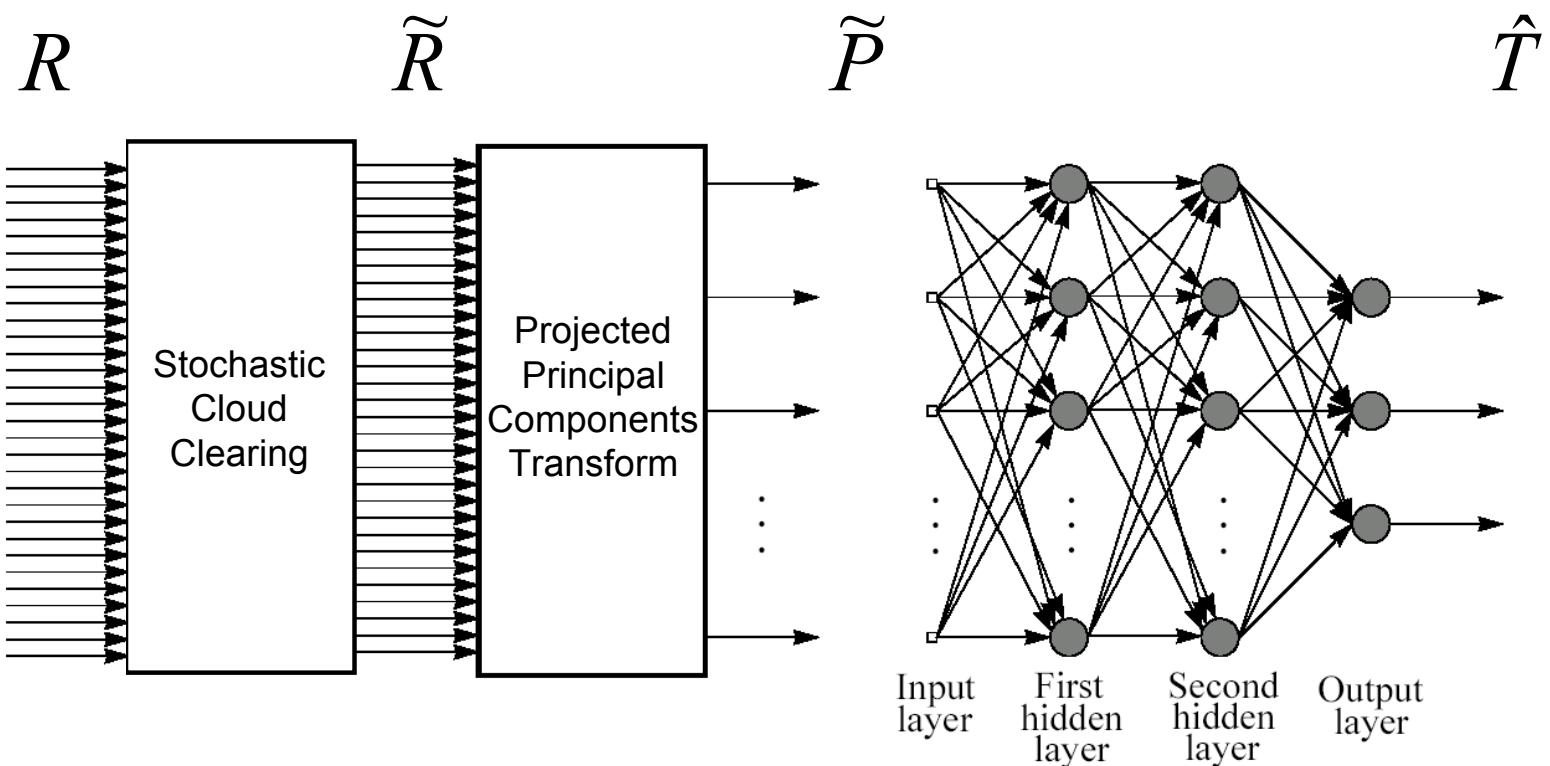


Algorithm Overview (Part II)

- Algorithm is composed of linear and non-linear statistical operators
 - Projected principal components transform
 - Neural network estimation
- Coefficients are derived empirically, off-line:
 - Co-location of sensor measurements with “truth” (Radiosondes, NWP, etc.)
 - Model-generated data
 - Data stratification is used for:
 - Sensor scan angle
 - Latitude
 - Solar zenith angle
 - Surface type
 - Surface elevation

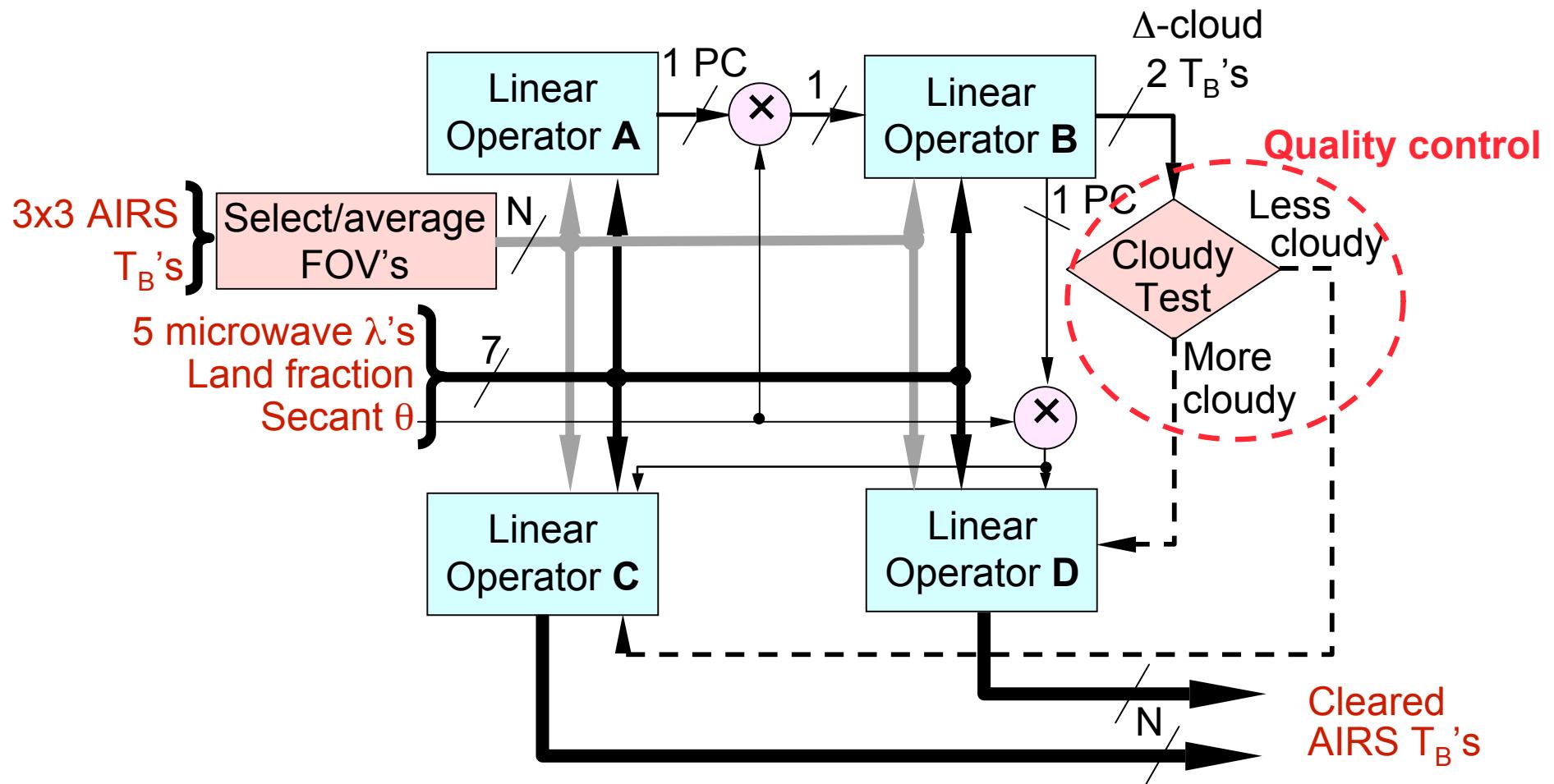


Algorithm Block Diagram





Block Diagram of SCC Algorithm



$N = 2378$ channels

Cho and Staelin, Aug. 2006

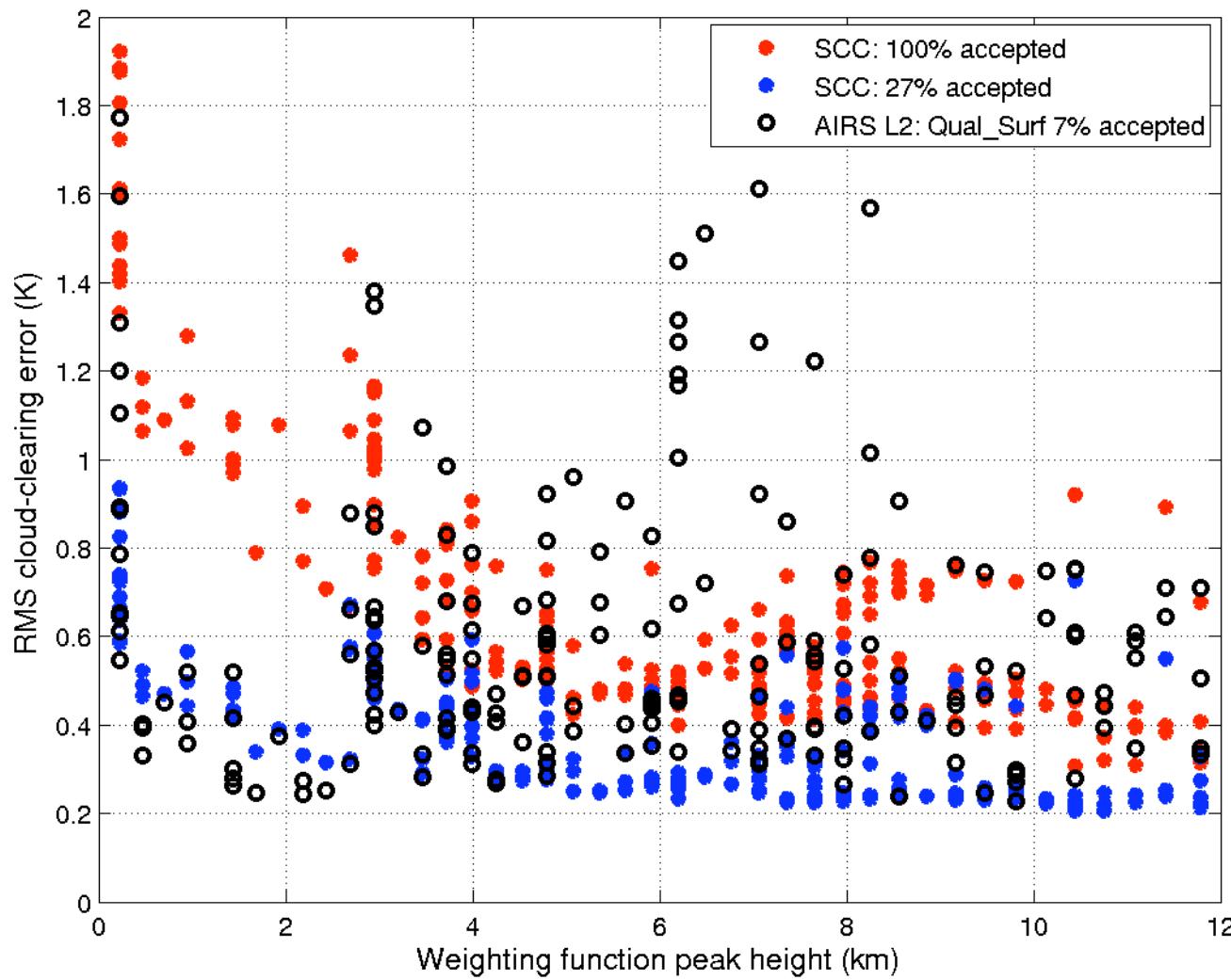


SCC+NN Quality Control

- **Simple, linear function of estimated radiance correction for a set of channels**
- **Framework allows for altitude-dependent quality flags**
- **Yield versus accuracy trades can be easily performed**
 - “Qual_Good” yields approximately 80%
 - “Qual_Best” yields approximately 30%



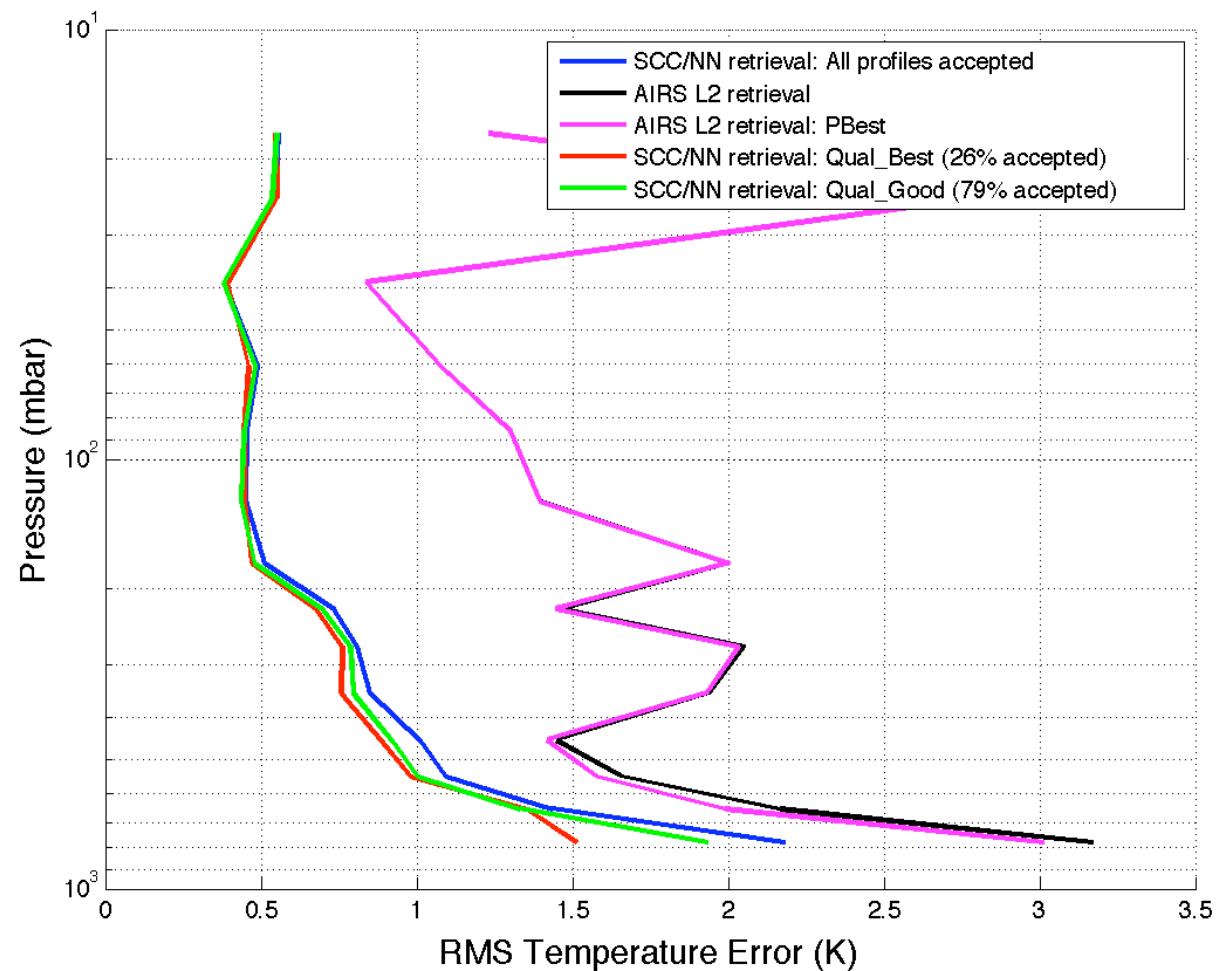
Stochastic Cloud Clearing Quality Control



Ocean, All latitudes



SCC/NN versus AIRS L2 (Version 5) Descending, South Pole*, Edge-of-Scan, Spring



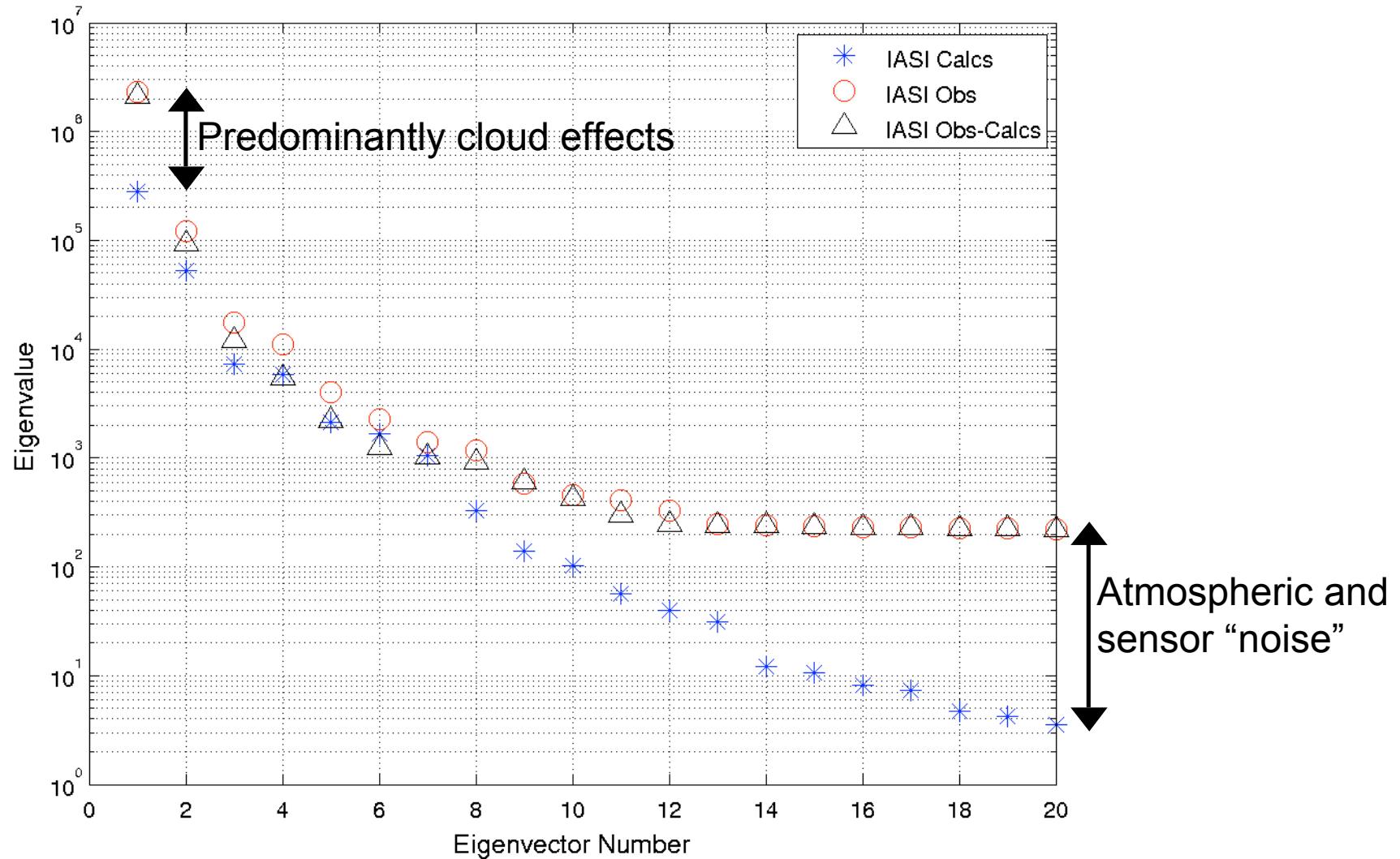
~1km vertical layers
AIRS+AMSU

ECMWF is “truth”
Quality is suspect

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IASI Eigenanalysis

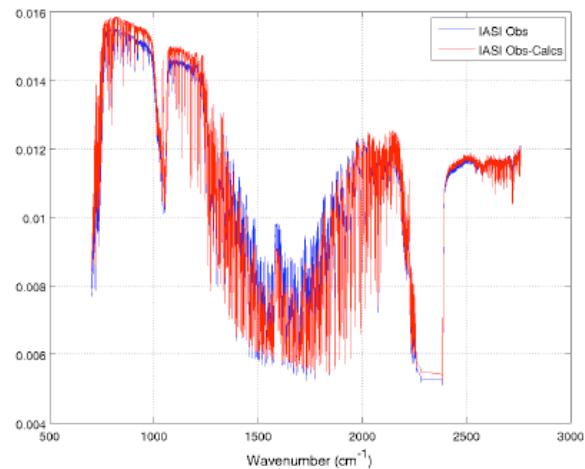


Ocean

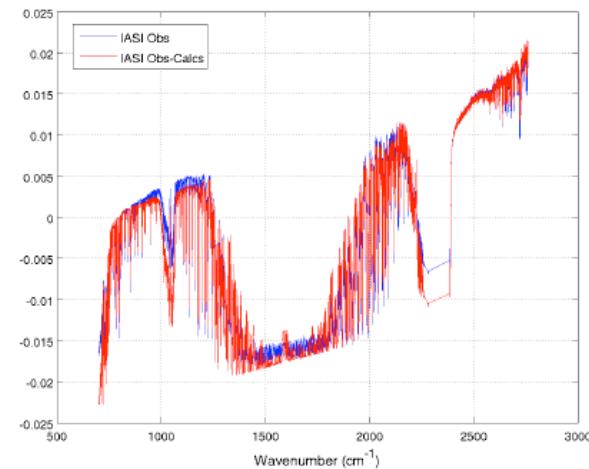
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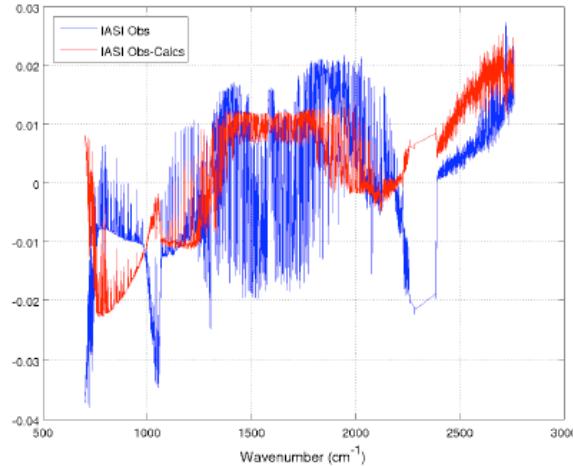
IASI “OBS” and “OBS-CALCS” Eigenvectors



(a) Eigenvector set #1



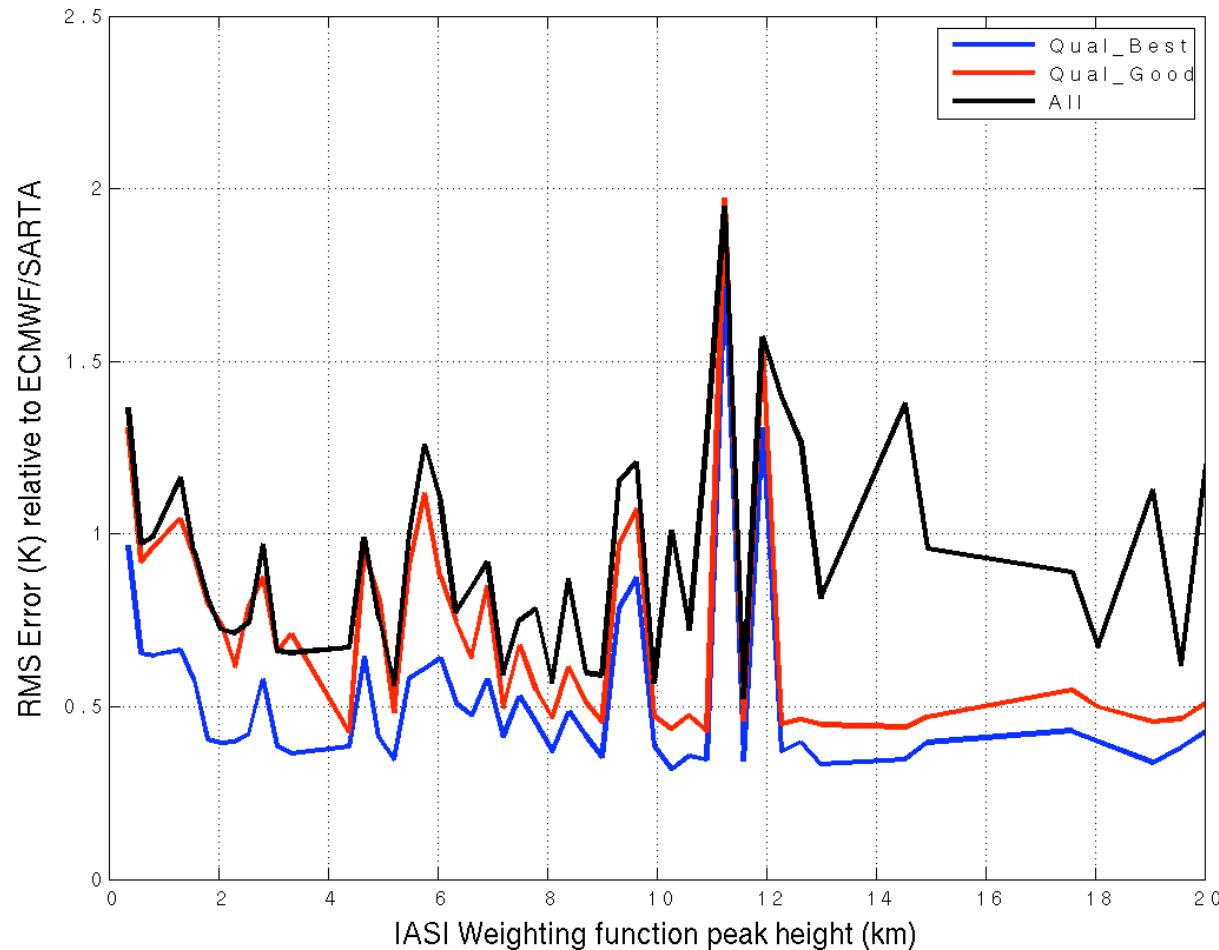
(b) Eigenvector set #2



(c) Eigenvector set #3



Stochastic Cloud Clearing of IASI



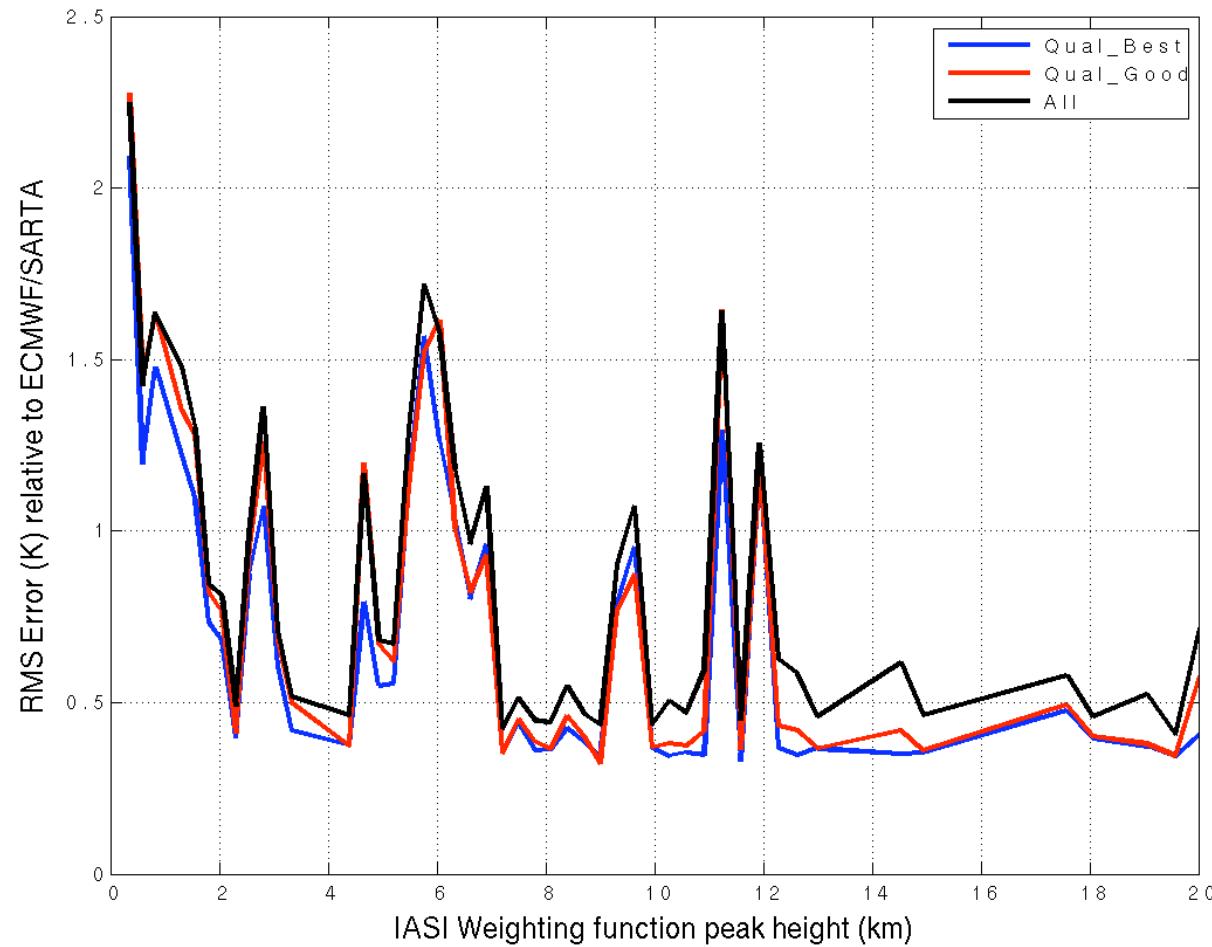
473 IASI channels were cleared
Descending orbits within $\pm 60^\circ$ latitude, ocean

ECMWF is “truth”

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Stochastic Cloud Clearing of IASI



**473 IASI channels were cleared
Descending orbits within $\pm 60^\circ$ latitude, land**

ECMWF is “truth”

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